

Proposed Outline for NATIONAL DEFENSE Magazine Article

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Modeling and Simulation at the Naval Surface Warfare Center

INTRODUCTION

Problem: A fleet exercise with live targets on a test range has an unexpected outcome. Combat system performance has been affected by outside events beyond the control of the test director. Time has become short, and the ships must now be diverted to other missions. The test range cannot be rescheduled due to other commitments. Questions about the validity of the exercise are raised.

Solution: Configure a constructive, personal computer-based model to model the performance parameters actually achieved in the live exercise. The outcome of the simulated battle, including detection and engagement statistics, is available within seconds. The analyst finds that the model substantiates the live exercise results. Complete technical and graphic data is formatted and immediately available for inclusion in a quick-look report. Direct cost of one hundred "simulated engagements", including setup and analysis: \$500.

EXAMPLE 2:

Problem: Conducting a live Joint Services exercise against a specific geographic military objective requires diverting large numbers of military units from existing missions and physically move them to an operating area. In addition to extraordinary direct costs, a massive amount of technical and administrative coordination is involved. Ships, aircraft, submarines and land-based units must be unilaterally diverted from existing missions and contingencies for an exclusive purpose

Solution: Create a "Synthetic Theater of War". Live units, hardware-in-the-loop simulations, and constructive models plug in to the Defense Simulation Internet using Distributed Interactive Simulation (DIS) protocol. Each sends "messages" onto the net describing their position, status, and events they cause to happen. Events include course changes, sensor detections, and weapon launches. Other units react to those simulated events on the Internet. Although the interaction is complete, none of the

players live or simulated, have physically moved. Costs, including fuel, travel, and meetings are minimized. Everyone goes home on time.

IMPORTANCE OF NAVY M&S TODAY

The above situations are common. The common thread is the dramatically reduced resources available to support these research, engineering, test and evaluation, and training situations. Less money is available throughout the Navy. Reduced numbers of ships now handle the same number of operational responsibilities, which limits training opportunities. Tightly compacted development schedules are reducing the time available for test. Last but not least, environmental responsibilities limit the extent of live testing.

All of these "drivers" dictate increased reliance upon modeling and simulation to support acquisition decisions. The Navy is responding. It is saving time, money, and assets through the use of focused Modeling and Simulation techniques. If M&S are done correctly, the need for live units to be involved in design experiments and test and evaluation is greatly reduced.

Policy changes within the Navy are underscoring this shift in emphasis. IN 1993, DOD formalized its approach to Modeling and Simulation by establishing the DOD Executive Council for Modeling and Simulation (EXCIMS) and the Defense Modeling and Simulation Office (DMSO). Successive echelons including OPNAV, NAVSEA, SPAWAR, NSWC, and others promptly responded with their individual implementing M&S Master Plans.

Commander, Operational Test and Evaluation Force recently issued a new Instruction promulgating procedures on the use of M&S in Operational Evaluations. It states, in part, "Complexity of systems ... continues to increase. The result is a spiraling increase in costs and time to test. Modeling and simulation ... presents an attractive alternative to reduce costs and time to field." The instruction formalizes OPTEVFOR requirements for thorough documentation, disciplined development, and formal verification, validation, and accreditation. In addition, the Instruction requires disciplined observation and review by the sponsor through technical and management panels.

4. NSWC TEAMING APPROACH The Naval Surface Warfare Center, created in 1991, consists of five major Divisions located at Carderock, MD; Crane, IN; Dahlgren, VA; Indian Head, MD; and Port Hueneme, CA. NSWC conducts its own initiatives designed to "do more with less". In 1992, NSWC Deputy Director Ira Blatstein conceived the NSWC Modeling and Simulation Team (MAST). The MAST consists of two representatives from each NSWC Division. It meets quarterly to share data, demonstrate local capabilities, and search for opportunities where two or more Divisions can "team" on a single M&S project. Teaming promotes cooperation

between the different divisions, minimizes duplicate efforts, and provides beneficial exposure of new and useful technologies.

5. NSWC M&S FACILITIES AND ASSETS

CARDEROCK (MD) Division provides leadership in Hull, Mechanical, and Electrical (HM&E) systems to provide Research, Development, Test, and Evaluation (RDT&E), In Service Engineering (ISE), and fleet support for surface and undersea vehicles, systems, and related maritime applications. The Division uses M&S for many aspects of R&D, acquisition support, and ISE including modeling of scientific phenomena, component, subsystem, system concepts as well as platform synthesis providing a solid foundation to conduct technology, ship, and force assessments.

CARDEROCK Division is an internationally recognized leader and developer of M&S for ship and submarine damage vulnerability, vehicle motion and maneuvering, computational fluid flow, finite element analyses, platform signatures, propulsion related machinery and systems, and platform design and integration. Its models support all stages of the acquisition process including DDG-51, LPD-17, SC 21, NSSN, SSN-21, and SSN-688. Additionally, the Division employs M&S to support the evaluation of advanced maritime concepts such as Marine Corps vehicles, platform design and construction, fleet training, and logistics. Future M&S initiatives include linking M&S efforts into a distributed networked environment to produce a total ship/submarine product model, simulation based design and virtual reality requiring distributed processing, secure networking systems, and links to the product models of other organizations.

CRANE (IN) DIVISION is the leader in modeling the many products that make up a weapon system. Crane Division modeling and simulation capability ranges from modeling of digital microcircuits, radar's and radar components, to modeling of pyrotechnics products such as decoy flares, as well as munitions effectiveness modeling for Navy special operations forces. Crane uses commercially available modeling tools to assure maximum compatibility with industry. In addition, Crane has deep-water simulation capability for Navy acoustic devices such as sonobuoys. The product modeling and simulation capability within the Crane Division is used across the entire life cycle of the weapon system. In the development and acquisition phase, modeling and simulation is used to assure designs can meet Navy performance and reliability requirements prior to construction and acceptance of the product. During the active life of the weapon system these same models are used to simulate failures for trouble shooting, evaluate product upgrades and to assure new technology can be inserted when replacement parts are no longer available due to technology obsolescence.

DAHLGREN (VA) Division is the leader in Combat System Research and Development within NSWC. It operates the widest range of Warfare Analysis Simulations, which address issues ranging from individual system engagement models up through multi-ship, multi-warfare theater and campaign models. Physics effects are studied through an equally wide range of phenomenological models addressing electromagnetic and acoustical propagation, missile guidance, ballistic projectiles, shock, vibration, hydrodynamics, and warhead blast effects. DAHLGREN maintains wrap-around simulation programs used for analysis of specific weapon systems such as AEGIS, SLQ-32, Vertical Launching System, and TOMAHAWK. Its test beds allow development simulation of the effects of multi sensor track integration, electromagnetic interference, telemetry, infrared guidance, anechoics, fiber optics, aerodynamics, and hydroballistics. It operates analysis models including a wargame facility, cost estimation models, life-cycle estimation models, force structure/deployment models, and an acquisition plan strategic model. DAHLGREN M&S supports tasks ranging from Cost and Operational Effectiveness Analyses for new ship classes, to very detailed design support of radar, electronic warfare, and missile systems.

The COASTAL SYSTEMS STATION, a detachment of DAHLGREN Division located at Panama City, FL, focuses on Mine Warfare, Special Warfare, Amphibious Warfare, Diving, and other missions which take place in the coastal region. The Coastal Mine warfare Evaluator (CME) is a Hardware-in-the-Loop, Real Time Simulation facility which simulates multiple interacting objects such as torpedoes, ships, mines, submarines, countermeasures, and decoys. The CME supports the full spectrum of RDT&E, allowing analysis and "what-if" studies of new sensor, vehicle, and weapon technologies. The CSS Mine Countermeasures and Tactics Facility (MATF) is a fully interactive, warfighter-in-the-loop, simulation and analysis asset.

Weapons simulation is an important function at INDIAN HEAD (MD) Division, which performs design/development/in-service engineering. The Weapons Engineering Department operates simulations of STANDARD MISSILE, HARPOON, VERTICAL LAUNCHING SYSTEM, and the TOMAHAWK Missile-in-Loop Functional Ground Testbed. Their products and services are used extensively for integration of new weapons into the platform, certification of launching/fire control systems, training in safe weapons handling, conduct of Daily System Operability Tests, conduct of realistic threat engagement/missile foring exercises, and diagnosis of launcher and fire control system problems. Some specific functions include detailed design and analysis of solid propellant rocket motors and related subsystems for development, qualification, production, and service life evaluation. Computer modeling predicts the trajectories of rocket motors and the loading on system components. Thrust and pressure are simulated in the computer. Heat transfer analysis is performed to predict temperatures and erosion/ablation of materials using thermochemical codes, computational fluid dynamics, and finite element analysis. Structural analysis

emphasized nonlinear techniques to represent the viscoelastic nature of solid propellant. Three-dimensional models of all designs are prepared using commercial CAD software. INDIAN HEAD Division performs all of its computer based modeling on UNIX based RISC Workstations. A network and parallel/multi-processor support the individual workstations. Beyond the primary Indian Head mission of rocket propulsion, modeling capabilities are also used to support a broad range of applications such as failure investigations (e.g. USS IOWA incident) and sizing emergency vents in buildings for explosive operations.

PORT HUENEME (CA) Division supports its Test and Evaluation, In-Service Engineering, and Logistics sponsors with a wide array of simulations. The Integrated Combat System Test Facility uses the Combat System Simulation (CSS) as a master controller of simulations of combat system elements such as SLQ-32, TAS, NATO SEASPARROW, MK 86, MK 92, SYS-2 and WDS. This combination of simulations allows functional integration, stress, and endurance testing of new and modified operational computer programs. PORT HUENEME Division is the developer of the Battle Force Tactical Training (BFTT) system. BFTT is a shipboard combat systems trainer, which generates a scenario, and then integrates and synchronizes the On Board Trainers for each sensor and weapon system on the ship. BFTT allows sailors to "train as they fight" on their own shipboard equipment, with their own combat systems team. Personal computer based ship self defense models have been used to develop tactics, evaluate HARPOON survivability against an enemy ship, and analyze technical aspects of the USS STARK incident. PHD maintains a highly successful constructive simulation of the SWY-1,2, and 3 self-defense systems. The PHD Emulation/Simulation/Maintenance Facility will soon house the Close-In Weapon System/Phalanx fire control computer interfaced with simulations of the search and track radar's, the operator consoles, and the Phalanx gun itself.

PORT HUENEME Division EAST COAST OPERATIONS, Dam Neck, VA, also uses CSS along with a host of computer, sensor, and weapons system simulators/emulators used for developing command and control computer programs for surface combatants. CSS has also been shared with NOSC San Diego.

6. NSWC TEAMING ACCOMPLISHMENTS AND FUTURE TECHNOLOGIES

Using constructive models, PORT HUENEME, DAHLGREN, and CARDEROCK Divisions are examining ways to predict the outcome of a planned fleet exercise, and then validate the results of the exercise after the fact.

DAHLGREN AND CARDROCK Divisions are teaming on the production of the SC-21 Cost and Operational Effectiveness Analysis document.

DAHLGREN Division has teamed with CSS Panama City, providing its MARS model for use in a Mine Warfare modeling project.

Representatives from each of the five NSWC Divisions jointly developed the NSWC Modeling and Simulation Master Plan.

The Naval Surface Warfare Center is aggressively pursuing technological advances. Examples of Distributed Interactive Simulation/Advanced Distributed Simulation abound.

NSWC has participated in a total of four Synthetic Theater of War (STOW) exercises, starting in 1994.

NSWC developers of BFTT participated in the Interservice/Industry Training Systems and Education Conference (I/ITSEC) where 30-plus companies and DOD components simultaneously exercise their public and proprietary simulations on a Distributed Interactive Simulation